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(54) **LIGHTING ASSEMBLY AND LIGHT MODULE FOR SAME**

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This patent is subject to a terminal disclaimer.

(21) Appl. No.: **13/464,191**

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Related U.S. Application Data

(63) Continuation of application No. 13/175,376, filed on Jul. 1, 2011, now Pat. No. 8,177,395, which is a continuation of application No. 12/986,934, filed on Jan. 7, 2011, now Pat. No. 7,972,054, which is a continuation of application No. 12/149,900, filed on May 9, 2008, now Pat. No. 7,866,850.

(60) Provisional application No. 61/064,282, filed on Feb. 26, 2008.

(51) **Int. Cl.**
F21V 29/00 (2006.01)

(52) **U.S. Cl.**
USPC **362/294**; 362/285; 362/287; 362/800; 362/147

(58) **Field of Classification Search**
USPC 362/294, 373, 198, 249.03, 249.07, 362/288, 289
See application file for complete search history.

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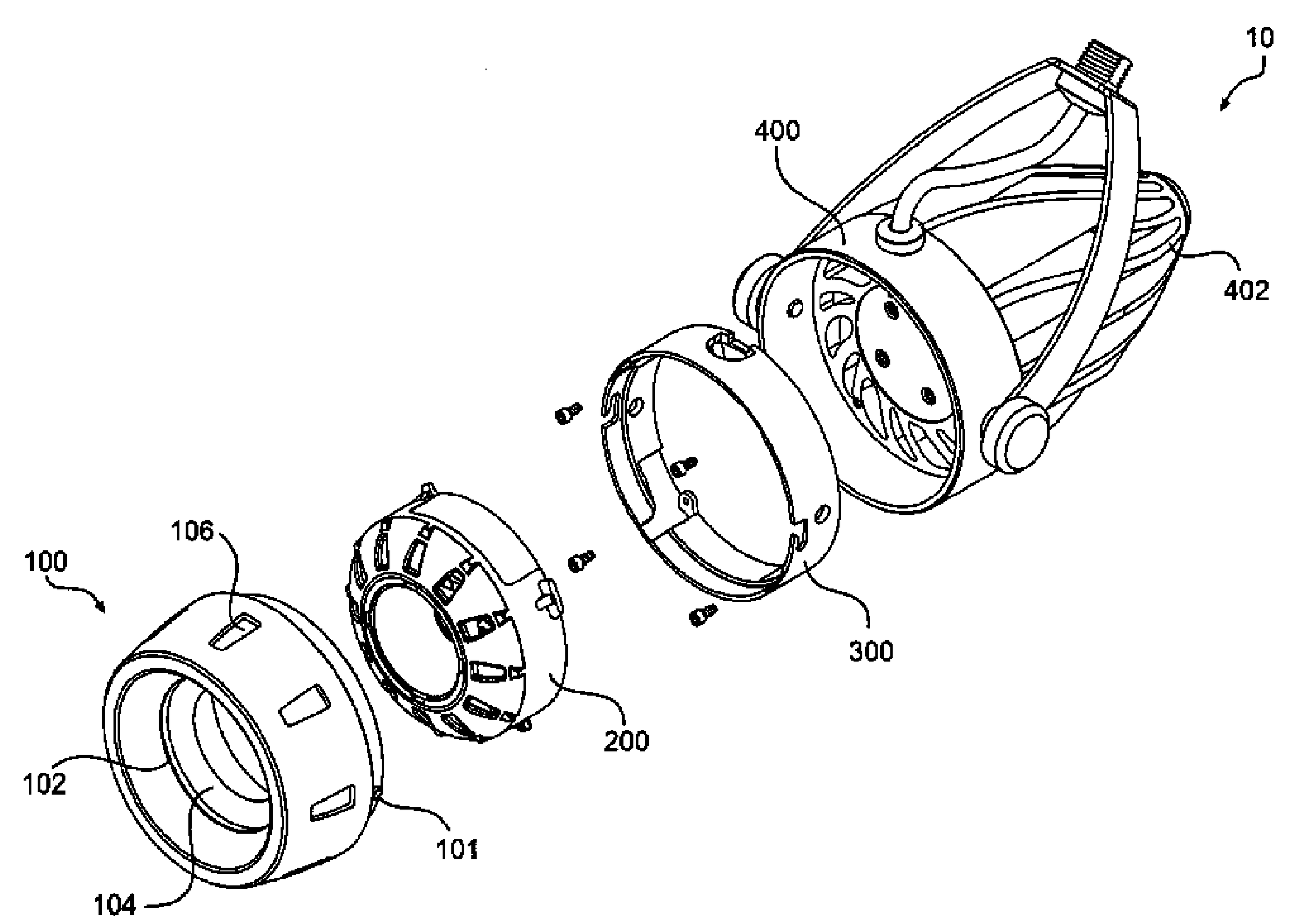
(57) **ABSTRACT**

A lighting assembly that has a light fixture and an LED light module is provided. One or more resilient members generate an axial force when the LED light module is removably coupled to the light fixture to thereby exert a force on the LED light module to resiliently maintain the LED light module in resilient contact with the light fixture or socket of the light fixture to thereby thermally couple the LED light module to the light fixture or socket of the light fixture. One or both of the LED light module and light fixture have one or more engaging members, and one or both of the LED light module and the light fixture have one or more slots configured to removably receive the one or more engaging members therein when coupling the LED light module to the light fixture.

28 Claims, 14 Drawing Sheets



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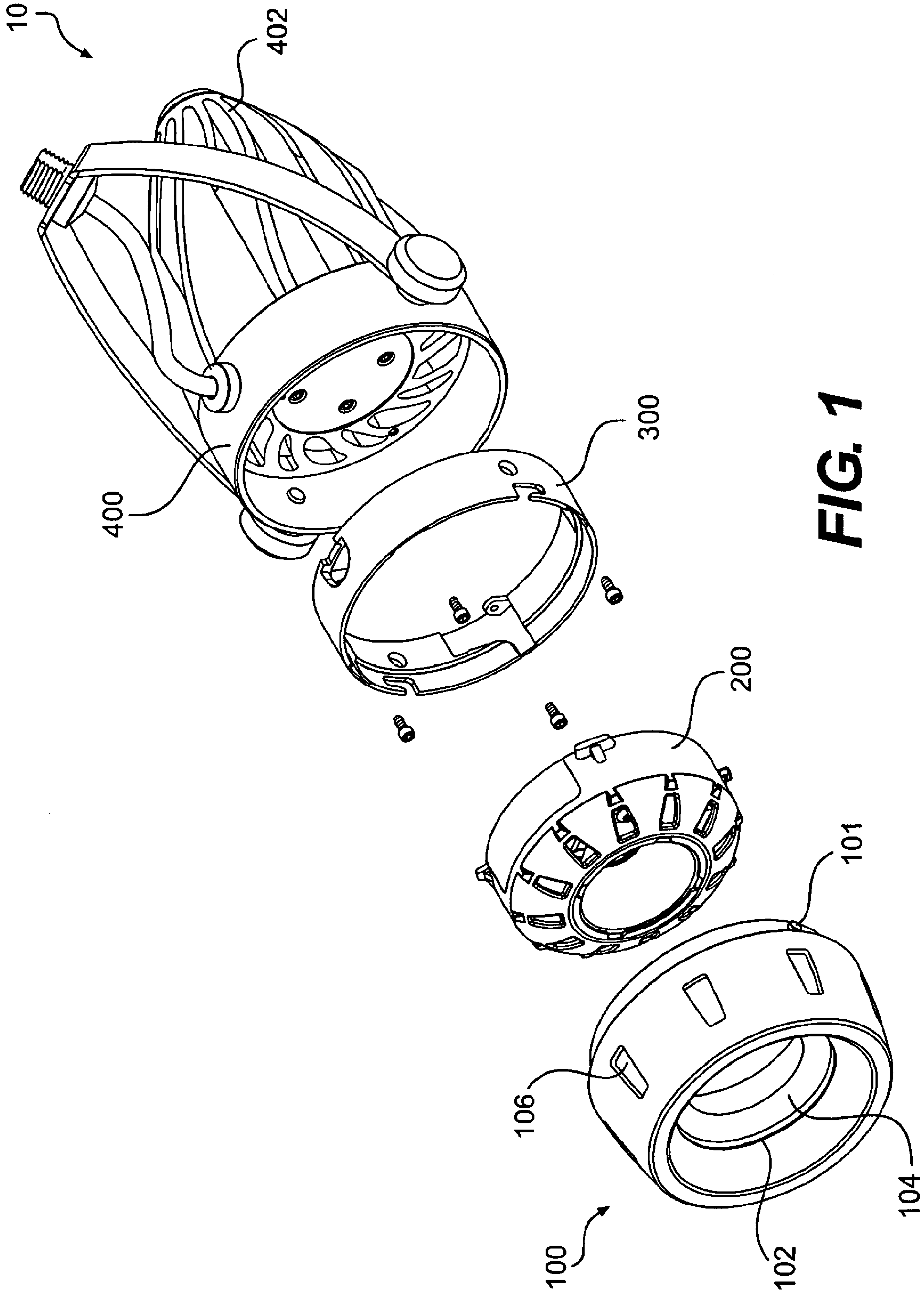

FIG. 1

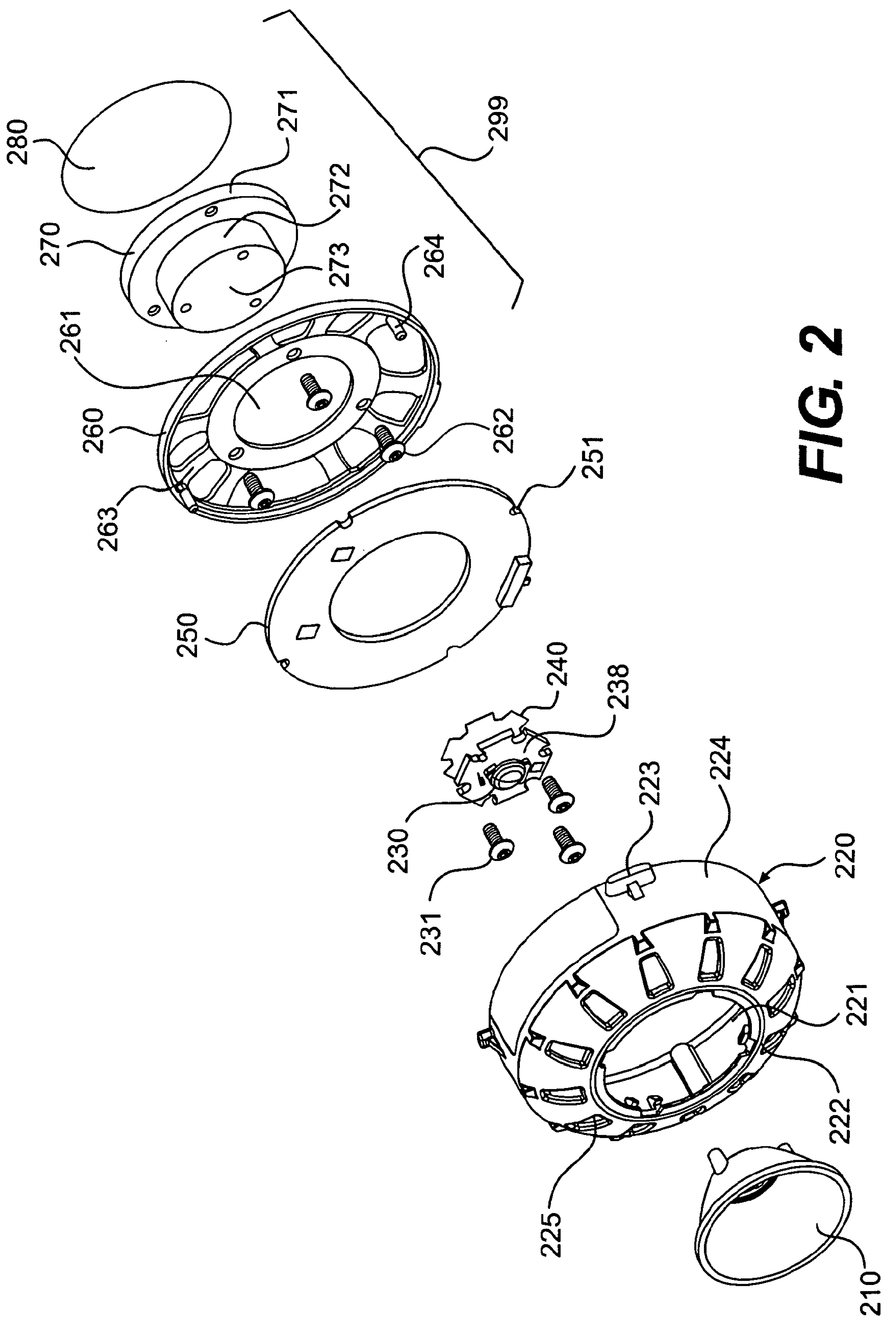

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FIG. 2

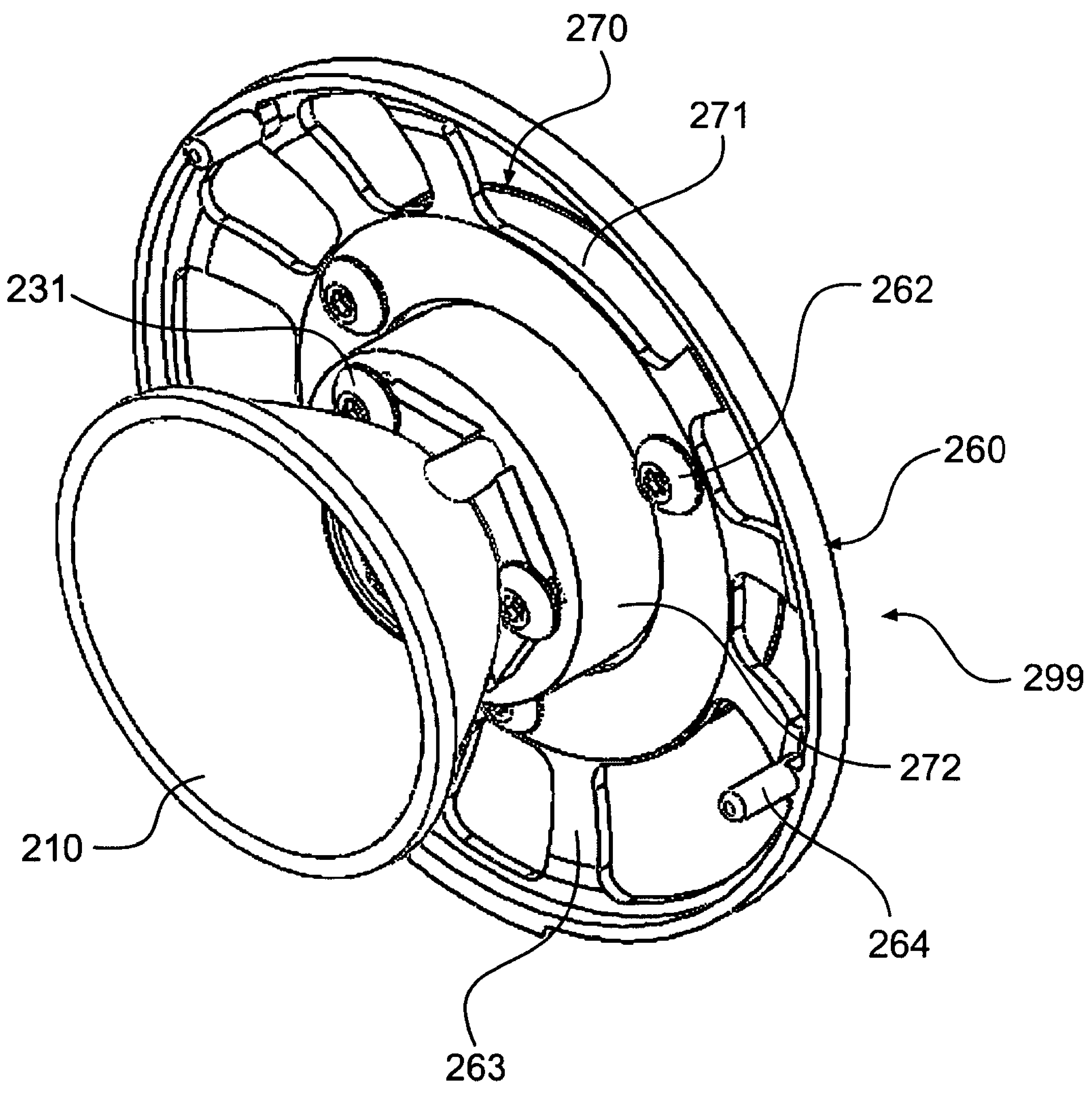

FIG. 3

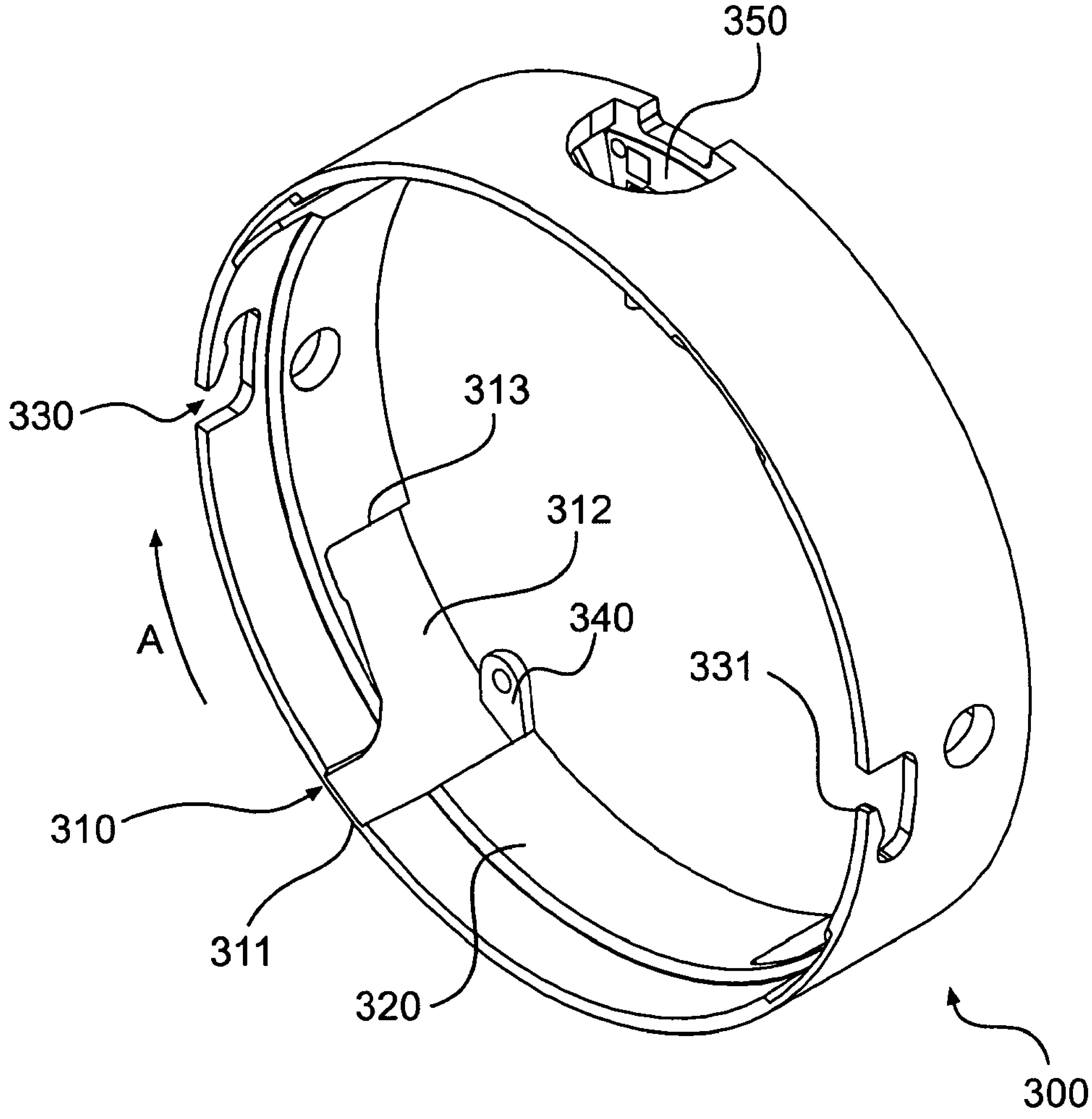

FIG. 4

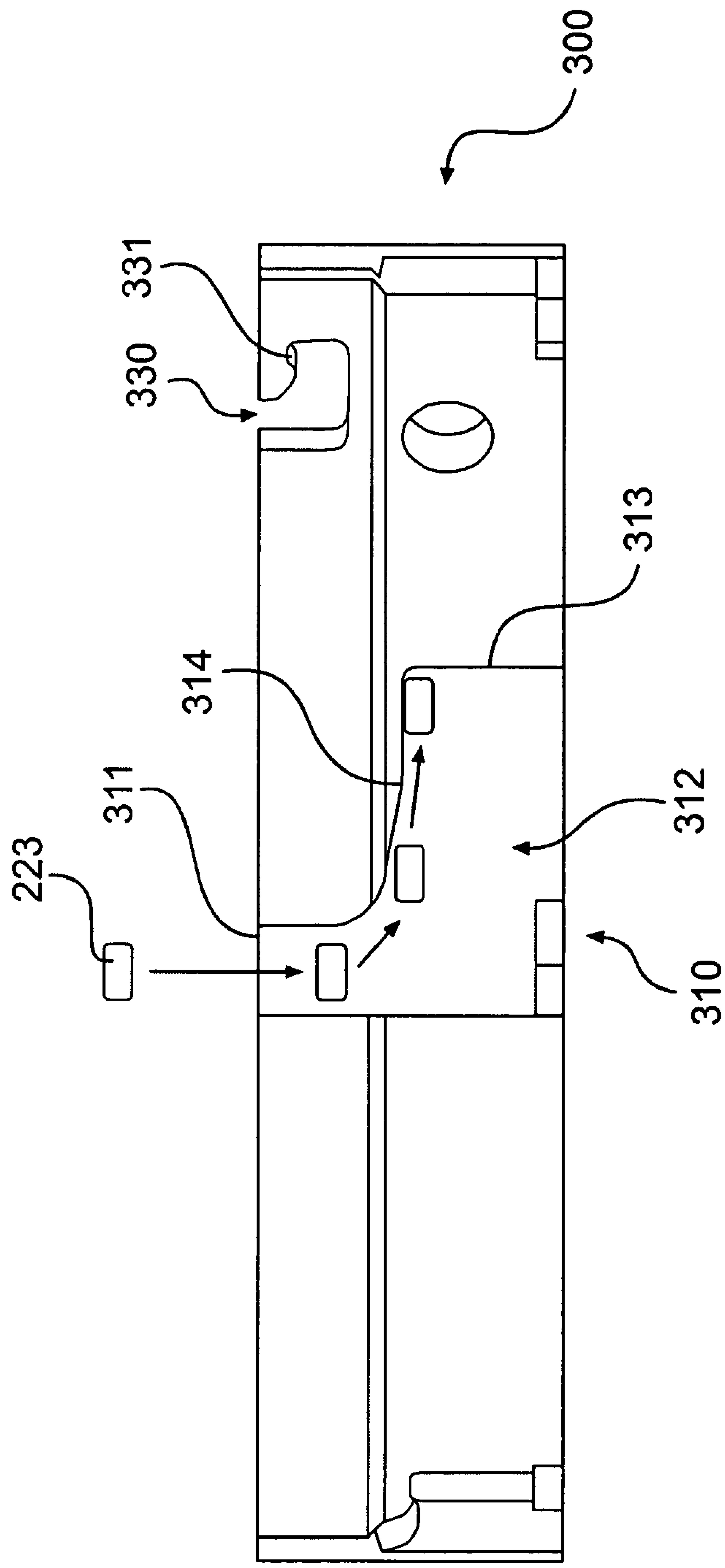

FIG. 5

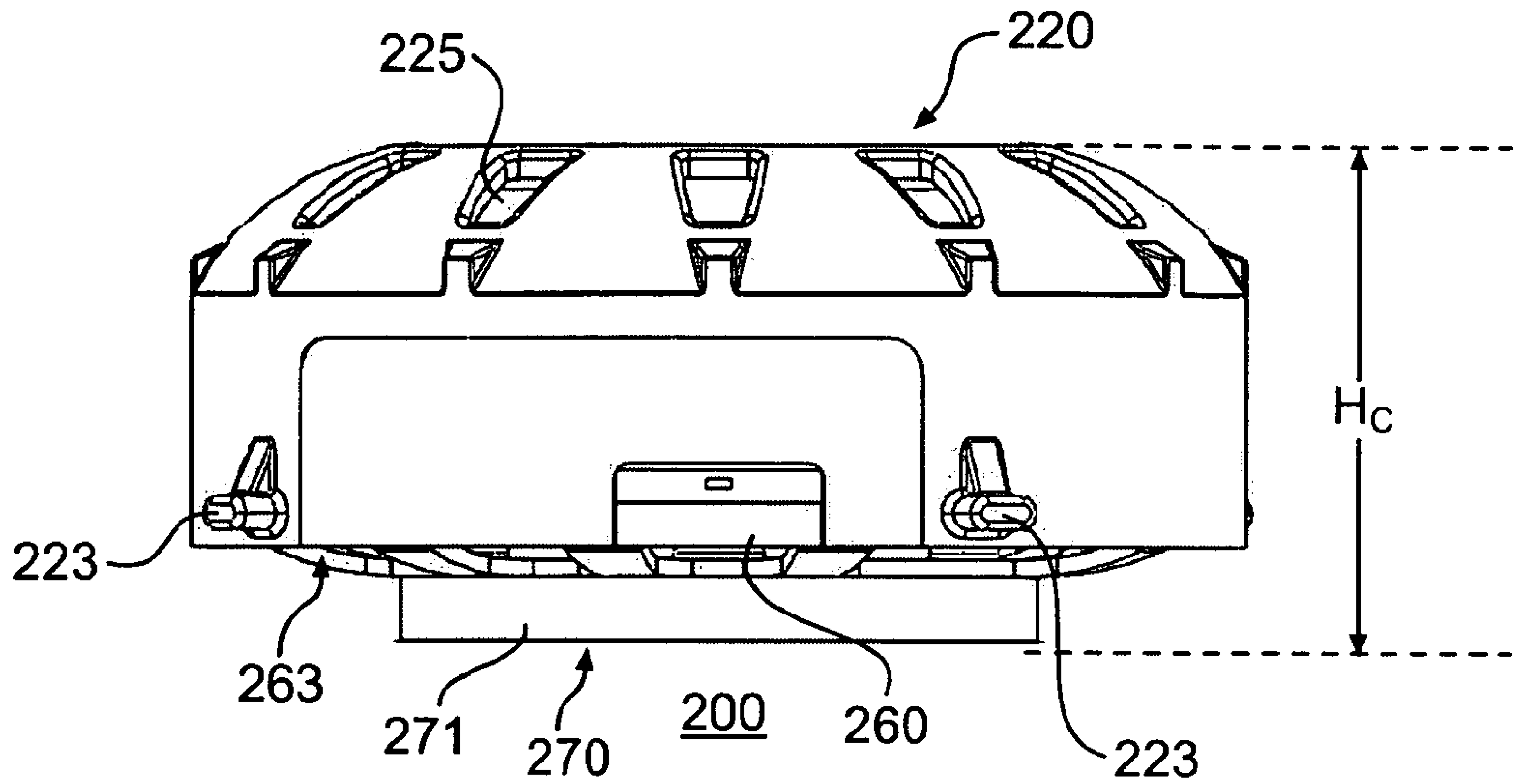

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FIG. 6A

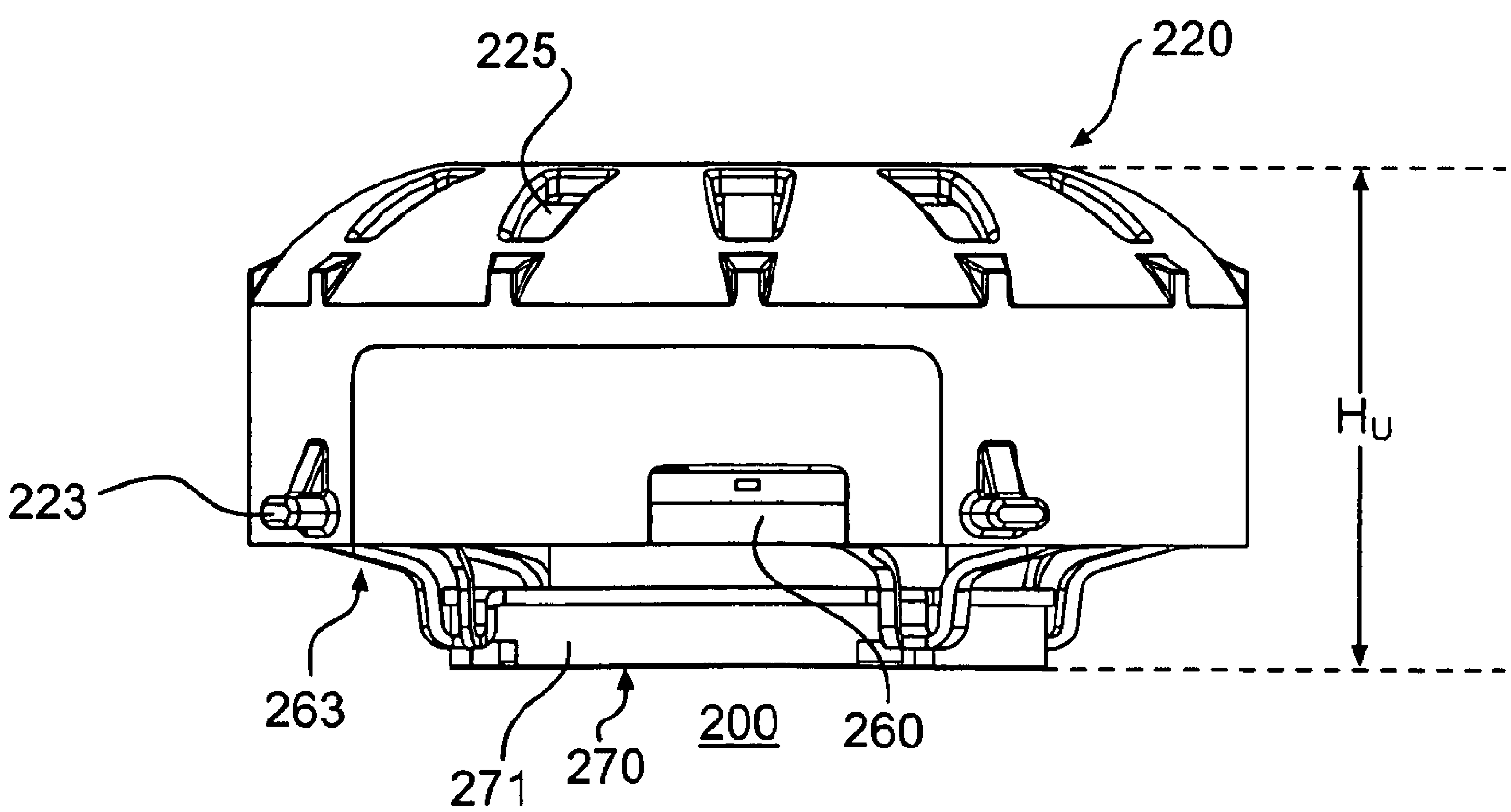

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FIG. 6B

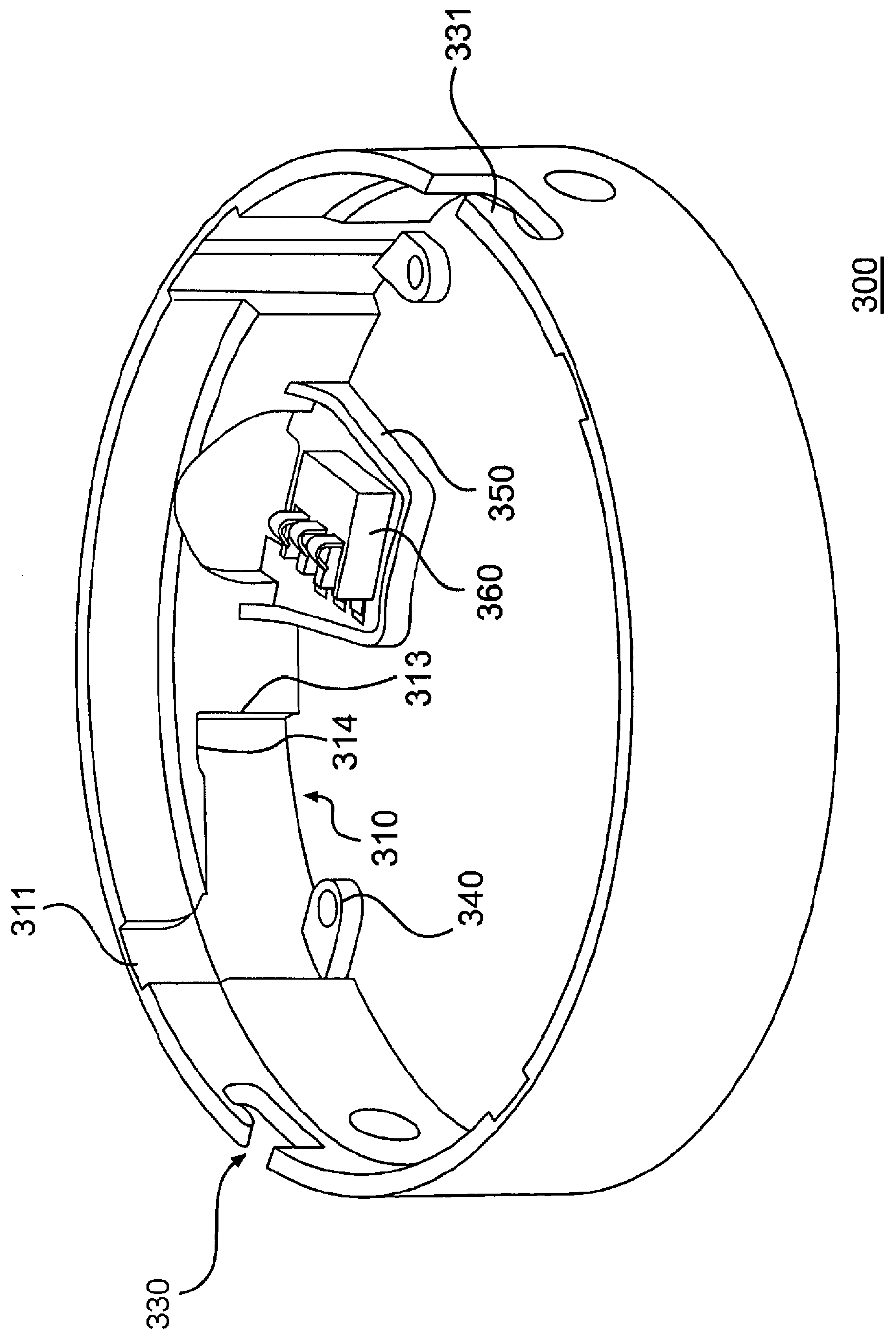

FIG. 7

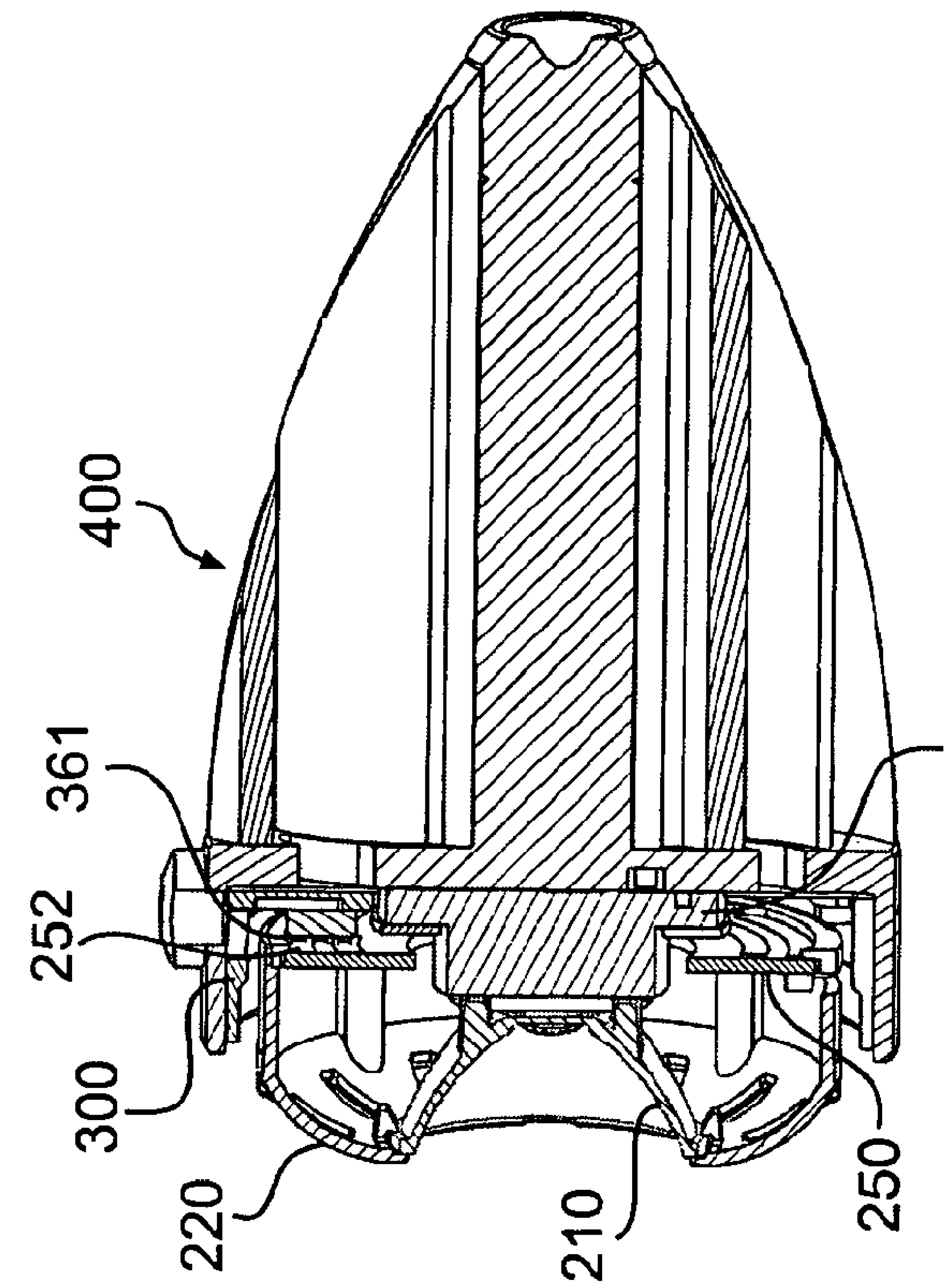

FIG. 8B

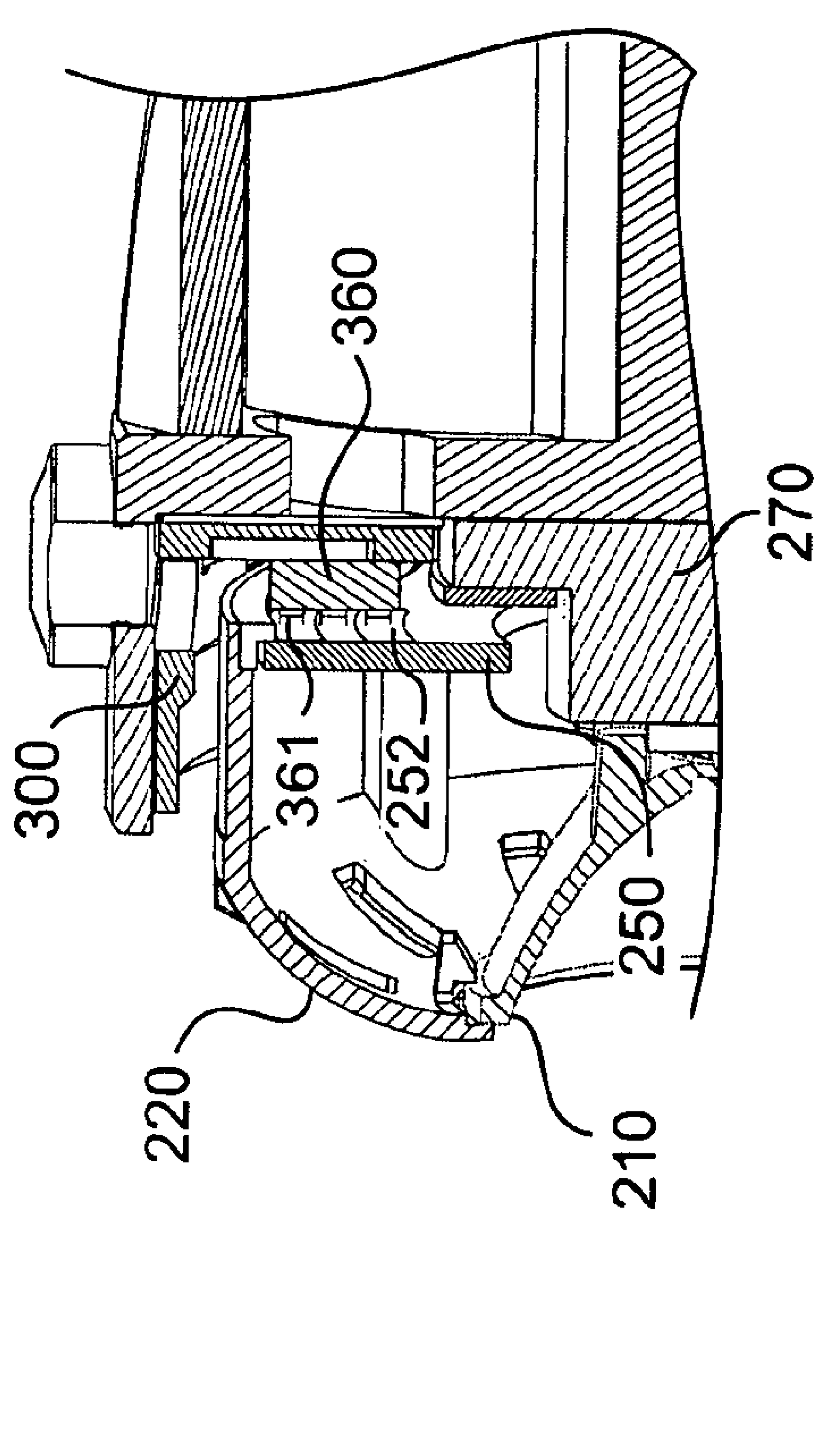

FIG. 8A

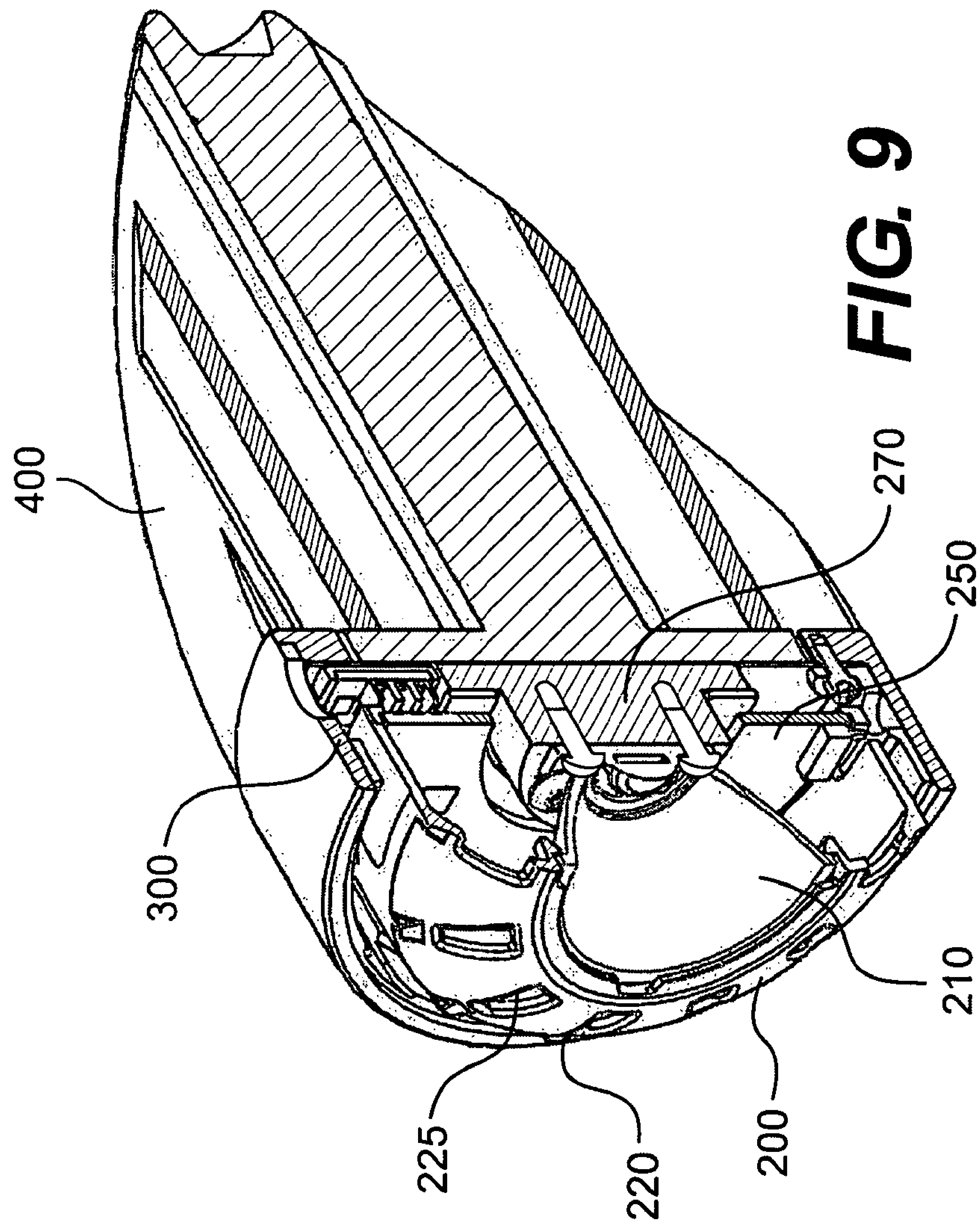

FIG. 9

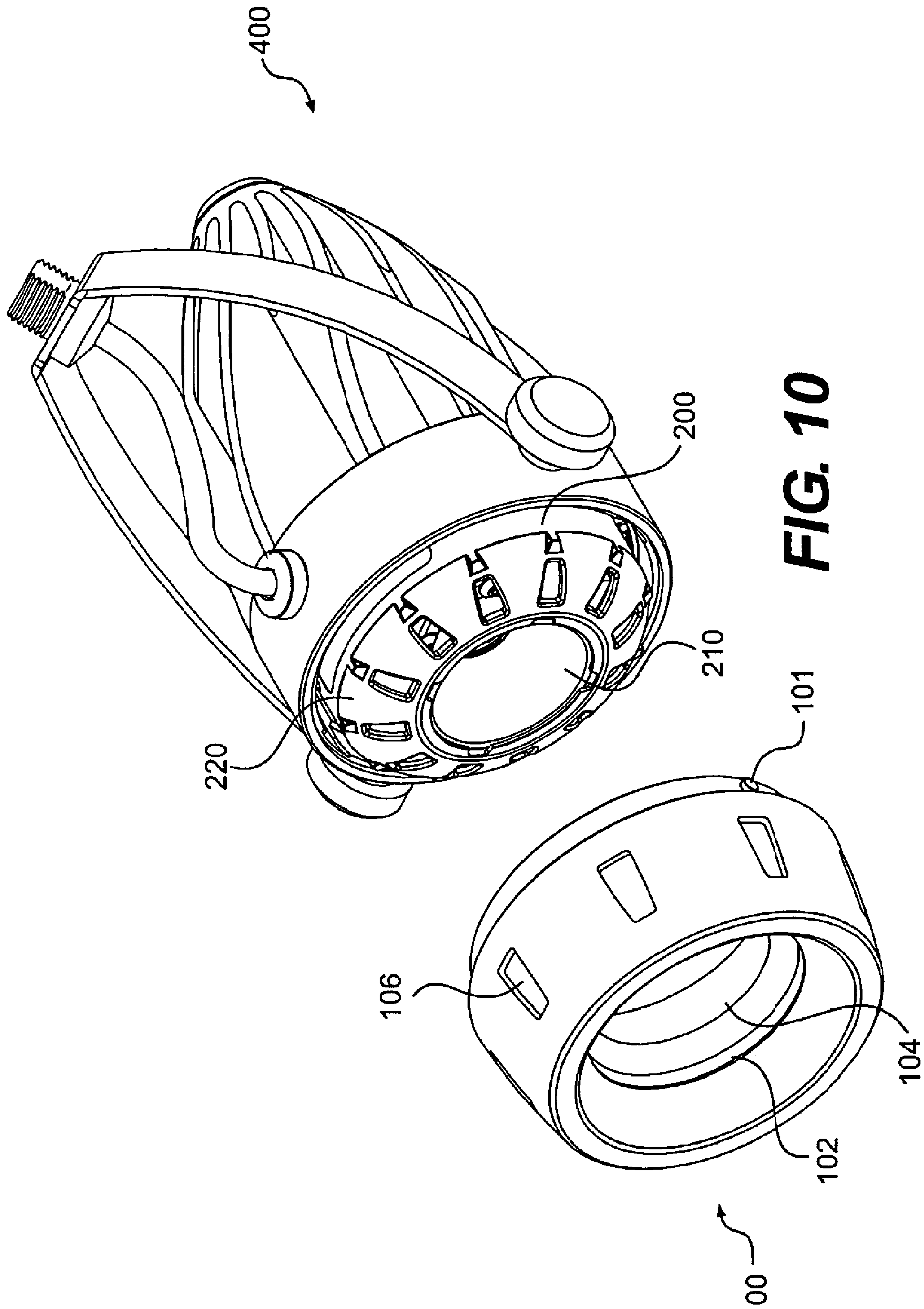

FIG. 10

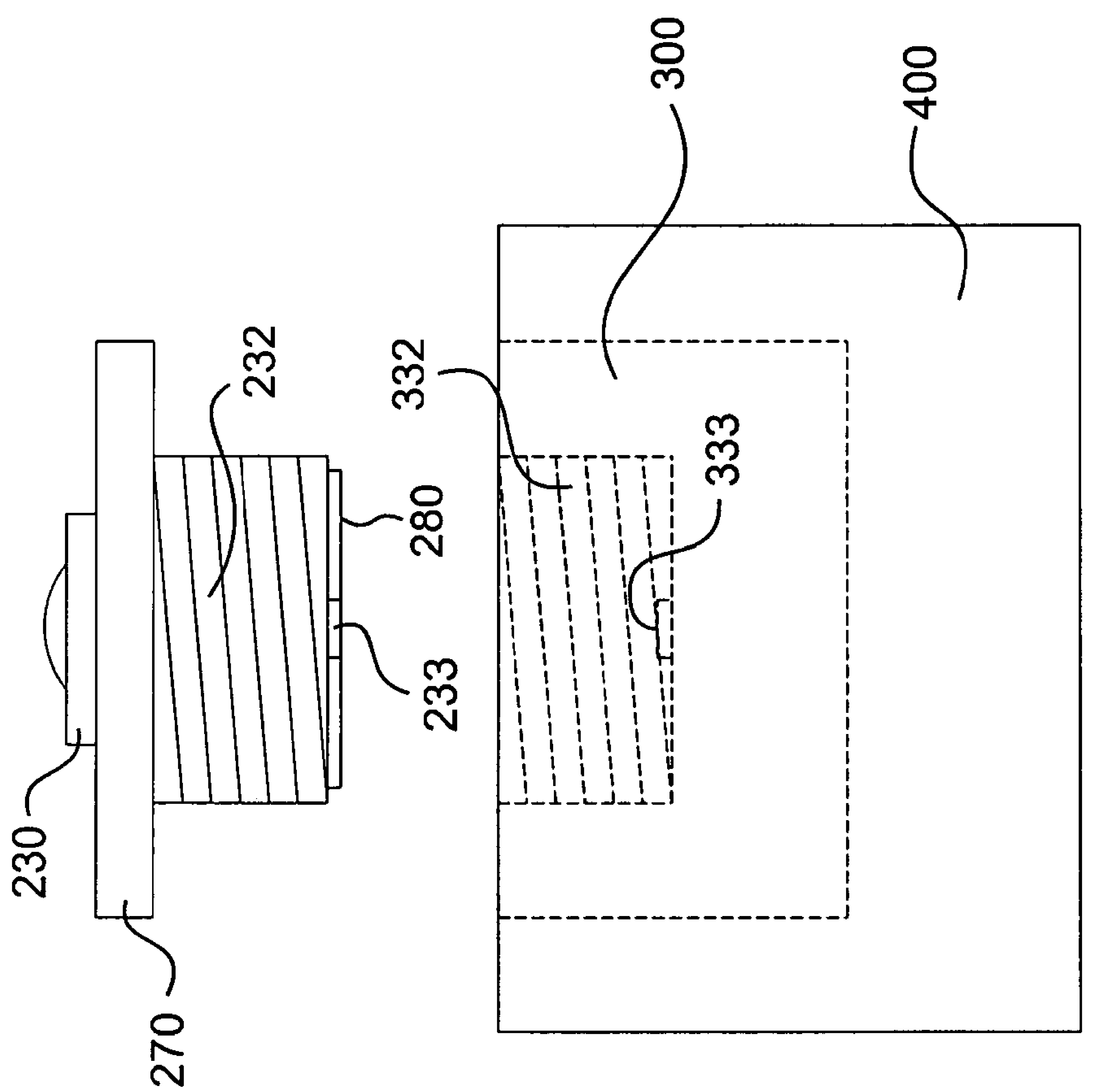

FIG. 11

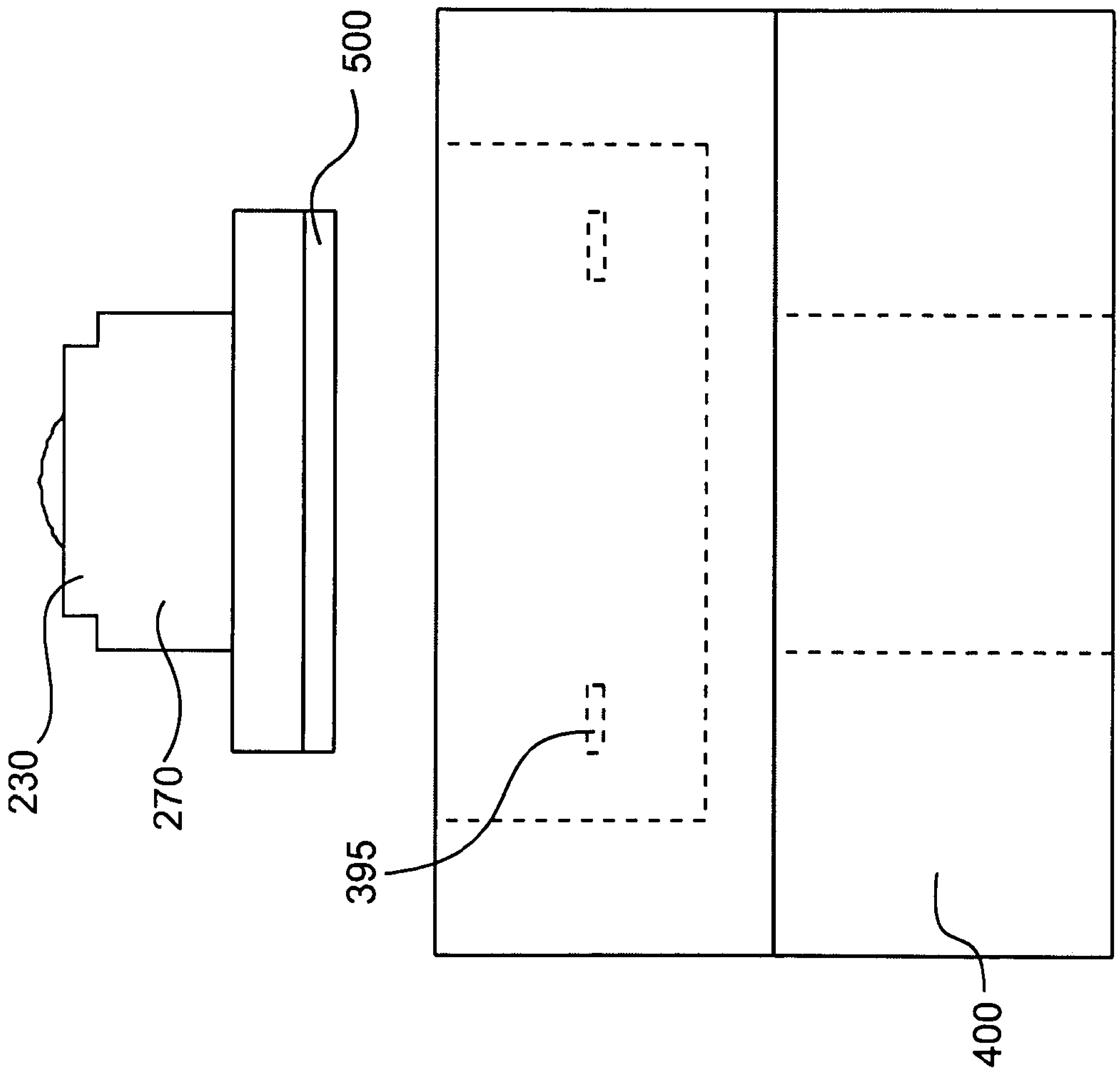

FIG. 12

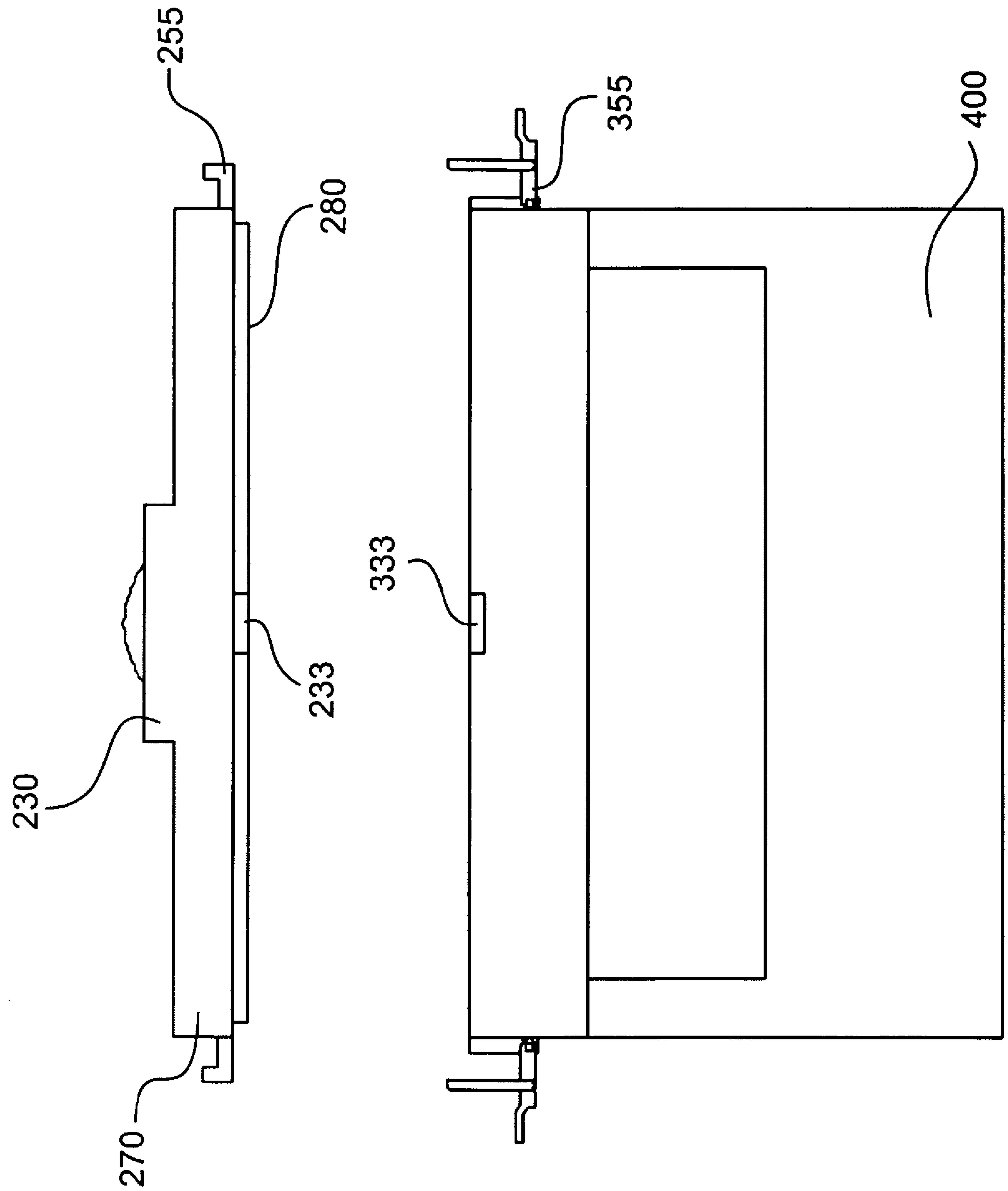

FIG. 13

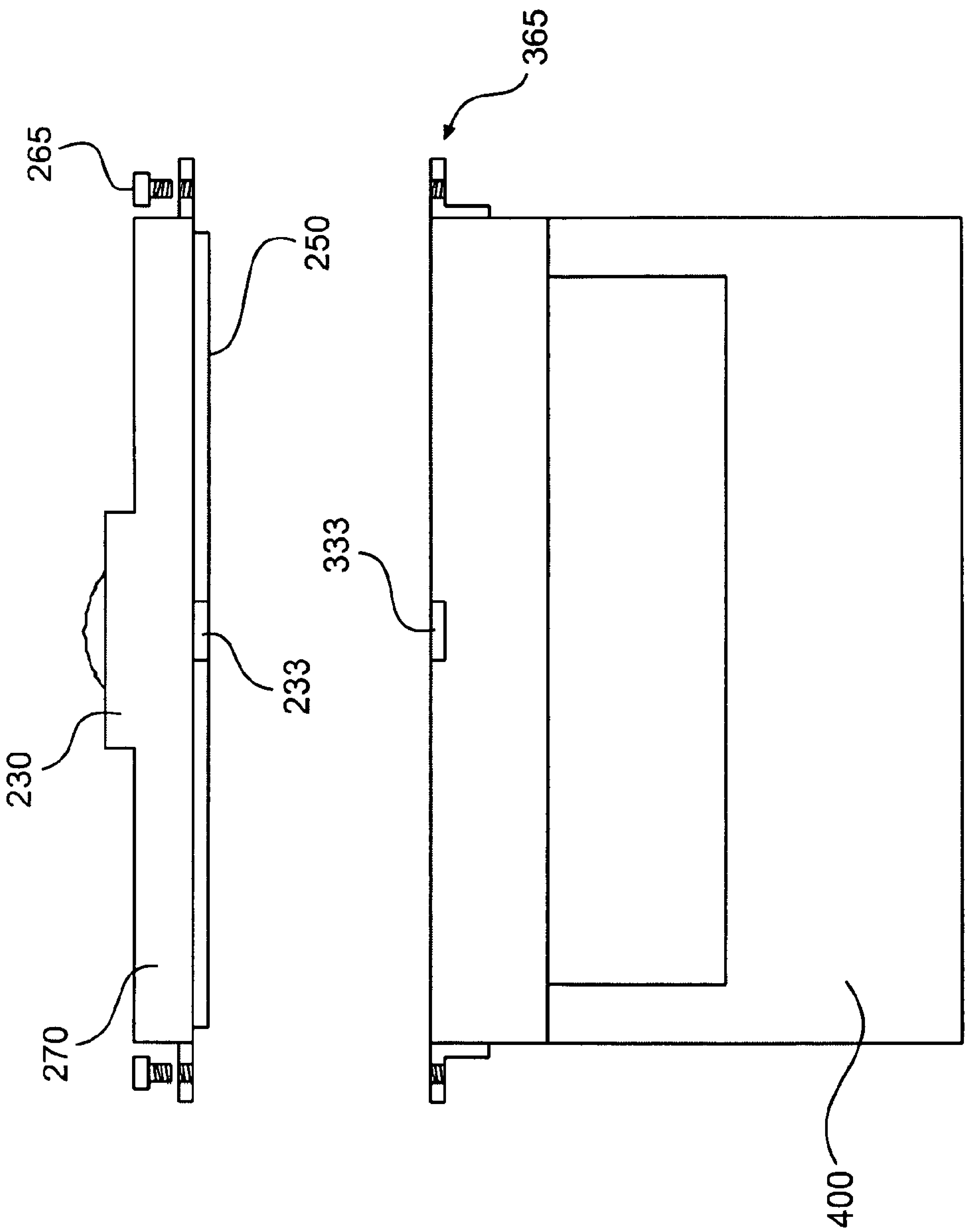

FIG. 14

LIGHTING ASSEMBLY AND LIGHT MODULE FOR SAME

PRIOR APPLICATION

This application is a continuation application of U.S. application Ser. No. 13/175,376, filed Jul. 1, 2011, which is a continuation application of U.S. application Ser. No. 12/986,934, filed Jan. 7, 2011, now U.S. Pat. No. 7,972,054, which is a continuation application of U.S. application Ser. No. 12/149,900, filed May 9, 2008, now U.S. Pat. No. 7,866,850, which claims the benefit of priority to U.S. Provisional Patent Application No. 61/064,282, filed Feb. 26, 2008, the entire contents of all of which are hereby incorporated by reference in their entirety.

BRIEF DESCRIPTION

1. Technical Field

The present invention is directed to an LED assembly that can be connected thermally and/or electrically to a light fixture assembly housing.

2. Background

Light fixture assemblies such as lamps, ceiling lights, and track lights are important fixtures in many homes and places of business. Such assemblies are used not only to illuminate an area, but often also to serve as a part of the decor of the area. However, it is often difficult to combine both form and function into a light fixture assembly without compromising one or the other.

Traditional light fixture assemblies typically use incandescent bulbs. Incandescent bulbs, while inexpensive, are not energy efficient, and have a poor luminous efficiency. To address the shortcomings of incandescent bulbs, a move is being made to use more energy-efficient and longer lasting sources of illumination, such as fluorescent bulbs, high-intensity discharge (HID) bulbs, and light emitting diodes (LEDs). Fluorescent bulbs and HID bulbs require a ballast to regulate the flow of power through the bulb, and thus can be difficult to incorporate into a standard light fixture assembly. Accordingly, LEDs, formerly reserved for special applications, are increasingly being considered as a light source for more conventional light fixture assemblies.

LEDs offer a number of advantages over incandescent, fluorescent, and HID bulbs. For example, LEDs produce more light per watt than incandescent bulbs, LEDs do not change their color of illumination when dimmed, and LEDs can be constructed inside solid cases to provide increased protection and durability. LEDs also have an extremely long life span when conservatively run, sometimes over 100,000 hours, which is twice as long as the best fluorescent and HID bulbs and twenty times longer than the best incandescent bulbs. Moreover, LEDs generally fail by a gradual dimming over time, rather than abruptly burning out, as do incandescent, fluorescent, and HID bulbs. LEDs are also desirable over fluorescent bulbs due to their decreased size and lack of need of a ballast, and can be mass produced to be very small and easily mounted onto printed circuit boards.

While LEDs have various advantages over incandescent, fluorescent, and HID bulbs, the widespread adoption of LEDs has been hindered by the challenge of how to properly manage and disperse the heat that LEDs emit. The performance of an LED often depends on the ambient temperature of the operating environment, such that operating an LED in an environment having a moderately high ambient temperature can result in overheating the LED, and premature failure of the LED. Moreover, operation of an LED for extended period of time at an intensity sufficient to fully illuminate an area may also cause an LED to overheat and prematurely fail.

Accordingly, high-output LEDs require direct thermal coupling to a heat sink device in order to achieve the advertised life expectancies from LED manufacturers. This often results in the creation of a light fixture assembly that is not upgradeable or replaceable within a given light fixture. For example, LEDs are traditionally permanently coupled to a heat-dissipating fixture housing, requiring the end-user to discard the entire assembly after the end of the LED's lifespan. As a solution, exemplary embodiments of a light fixture assembly may transfer heat from the LED directly into the light fixture housing through a compression-loaded member, such as a thermal pad, to allow for proper thermal conduction between the two. Additionally, exemplary embodiments of the light fixture assembly may allow end-users to upgrade their LED engine as LED technology advances by providing a removable LED light source with thermal coupling without the need for expensive metal springs during manufacture, or without requiring the use of excessive force by the LED end-user to install the LED in the light fixture housing.

Exemplary embodiments of a light fixture assembly may include (1) an LED assembly and (2) an LED socket. The LED assembly may contain a first engagement member, and the socket may contain a second engagement member, such as angled slots. When the LED assembly is rotated, the first engagement member may move down the angled slots such that a compression-loaded thermal pad forms an interface with a light fixture housing. This compressed interface may allow for proper thermal conduction from the LED assembly into the light fixture housing. Additionally, as the LED assembly rotates into an engagement position, it connects with the LED socket's electrical contacts for electricity transmission. Thus, the use of the compressed interface may increase the ease of operation, and at the same time allow for a significant amount of compression force without the need of conventional steel springs. Further, the LED assembly and LED socket can be used in a variety of heat dissipating fixture housings, allowing for easy removal and replacement of the LED. While in some embodiments the LED assembly and LED socket are shown as having a circular perimeter, various shapes may be used for the LED assembly and/or the LED socket.

SUMMARY

Consistent with the present invention, there is provided a thermally-conductive housing; a removable LED assembly, the LED assembly comprising an LED lighting element; and a compression element, operation of the compression element from a first position to a second position generating a compression force causing the LED assembly to become thermally and electrically connected to the housing.

Consistent with the present invention, there is provided an LED assembly for a light fixture assembly, the light fixture assembly having a thermally-conductive housing, a socket attached to the housing, and a first engaging member, the LED assembly comprising: an LED lighting element; a resilient member; and a second engaging member adapted to engage with the first engaging member; operation of the LED assembly and the socket relative to each other from an alignment position to an engaged position causing the first engaging member to engage the second engaging member and the resilient member to create a compression force to reduce thermal impedance between the LED assembly and the housing.

Consistent with the present invention, there is provided a method of manufacturing a light fixture assembly, the method comprising forming an LED assembly including an LED lighting element and a first engaging member; forming a socket attached to a thermally-conductive housing, the socket comprising a second engaging member adapted to engage with the first engaging member; and moving the LED assembly and the socket relative to each other from an alignment position to an engaged position, to cause the first engaging member to engage with the second engaging member and create a compression force establishing an electrical contact and a thermal contact between the LED assembly and a fixture housing.

Consistent with the present invention, there is provided a light fixture assembly comprising a thermally-conductive housing; a socket attached to the housing and comprising a first engaging member; and an LED assembly, comprising: an LED lighting element; a resilient member; and a second engaging member adapted to engage with the first engaging member; the LED assembly and the socket being movable relative to each other from an alignment position to an engaged position; the first engaging member, in the engaged position, engaging the second engaging member and fixedly positioning the LED assembly relative to the socket; and the resilient member, in the engaged position, creating a compression force forming an electrical contact and a thermal contact between the LED assembly and the housing.

In accordance with one embodiment, a lighting assembly is provided comprising a light fixture and a light module comprising an LED lighting element and removably coupleable to the light fixture. The lighting assembly also comprises one or more resilient members configured to generate an axial force when the light module is removably coupled to the light fixture to thereby exert a force on at least a portion of the light module to resiliently maintain at least a portion of the light module in resilient contact with a surface of the light fixture or socket of the light fixture to thereby thermally couple at least a portion of the light module to the light fixture or socket of the light fixture. One or both of the light module and light fixture comprises one or more engaging members that extend from a surface thereof, and one or both of the light module and the light fixture comprises one or more slots configured to removably receive the one or more engaging members therein when coupling the light module to the light fixture.

In accordance with another embodiment, a light module removably coupleable to a light fixture is provided. The light module comprises a generally cylindrical housing and an LED lighting element at least partially disposed in the housing. The light module also comprises one or more electrical contact members configured to releasably contact one or more electrical contacts of a socket of a light fixture to provide an operative electrical connection between the light module and the socket of the light fixture when the light module is coupled to the light fixture. The light module also comprises one or more engaging members on the housing, the engaging members configured to releasably engage corresponding one or more engaging elements in the socket of the light fixture when coupling the light module to the socket. The engagement of the engaging members with the engaging elements of the socket generates an axial force that maintains at least a portion of the light module into resilient contact with a surface of a light fixture or socket of the light fixture when coupling the light module to the socket to thereby thermally couple the light module to the light fixture or socket of the light fixture.

In accordance with another embodiment, a light module for use in a lighting assembly is provided. The light module comprises an LED lighting element, and a thermal interface member operatively coupled to the LED lighting element. The thermal interface member is configured to contact one or more thermally conductive surfaces of at least one of a socket and a heat dissipating member of the lighting assembly when the LED module is coupled to the socket. The light module further comprises one or more resilient members configured to move from a first position to a second position to generate an axial force between the LED module and at least one of the socket and the heat dissipating member when the LED module is coupled to the socket, thereby causing the LED module to thermally contact said one or more thermally conductive surfaces. The light module also comprises one or more electrical contact members of the LED module configured to releasably contact one or more electrical contacts of the socket when the LED module is coupled to the socket to thereby provide an operative electrical connection to the LED.

In accordance with yet another embodiment, a method for coupling a light module to a light fixture is provided. The method comprises aligning one or more tabs in one or both of the light module and a socket of the light fixture with one or more slots in one or both of the light module and the socket of the light fixture. The method also comprises axially introducing at least a portion of the light module into a cylindrical recess of the socket such that the one or more tabs axially advance into at least a portion of the one or more slots. The method also comprises rotating the light module relative to the socket such that the one or more tabs movably engage an inclined portion of the one or more slots, the inclined portion of the one or more slots being inclined such that at least a portion of the light module moves axially toward a bottom of the socket as the light module is rotated relative to the socket. The method also comprises generating a compression force as the light module is rotated relative to the socket to thereby exert a generally axial force on at least a portion of the light module to resiliently maintain at least a portion of the light module into resilient contact with the light fixture or socket of the light fixture.

In accordance with still another embodiment, a lighting assembly is provided comprising a heat dissipating member comprising a socket having a first threaded portion. The lighting assembly also comprises an LED module comprising an LED lighting element and a second threaded portion. The LED module and the locket are rotationally movable relative to each other from a disengaged position to an engaged position to couple the first and second threaded portions which establishes a thermal path from the LED module to the heat dissipating member or socket of the heat dissipating member. A compression element in one or both of the socket and the LED module and/or the threaded portions is configured to maintain a compression force between the LED module and the socket when coupling the LED module to the socket.

In accordance with yet another embodiment, a removable LED module for use with a lighting assembly is provided. The LED module comprises and LED lighting element and one or more electrical contact members of the LED module configured to releasably contact one or more electrical contacts of a socket of the lighting assembly when coupling the LED module to the socket. The LED module further comprises one or more resilient members configured to move from a first position to a second position when coupling the LED module to the socket to generate a compression force to thereby exert a generally axial force on at least a portion of the light module to resiliently maintain at least a portion of the light module in resilient contact with the light fixture or socket of the light fixture to thereby thermally couple at least a portion of the light module to the light fixture or socket of the light fixture.

It is to be understood that both the foregoing general description and the following detailed description are exemplary and explanatory only and are not restrictive of the invention, as claimed.

The accompanying drawings, which are incorporated in and constitute a part of this specification, illustrate embodiments consistent with the invention and together with the description, serve to explain the principles of the invention.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is an exploded perspective view of a light fixture assembly consistent with the present invention;

FIG. **2** is an exploded perspective view of an LED assembly of the light fixture assembly of FIG. **1**;

FIG. **3** is a detailed perspective view of the second shell of the LED assembly of FIG. **2**;

FIG. **4** is a perspective view of a socket of the light fixture assembly of FIG. **1**;

FIG. **5** is a side view of the socket showing the travel of an engaging member of the LED assembly of FIG. **2**;

FIG. **6**A is a side view of the LED assembly of FIG. **2** in a compressed state;

FIG. **6**B is a side view of the LED assembly of FIG. **2** in an uncompressed state;

FIG. **7** is a perspective view of the LED socket of FIG. **4**;

FIGS. **8**A-**8**B are cross-sectional views of the light fixture assembly of FIG. **1**;

FIG. **9** is a perspective cross-sectional view of the light fixture assembly of FIG. **1**;

FIG. **10** is a perspective view of the light fixture assembly of FIG. **1**;

FIG. **11** is a front view of a light fixture assembly according to a second exemplary embodiment;

FIG. **12** is a front view of a light fixture assembly according to a third exemplary embodiment;

FIG. **13** is a front view of a light fixture assembly according to a fourth exemplary embodiment; and

FIG. **14** is a front view of a light fixture assembly according to a fifth exemplary embodiment.

DETAILED DESCRIPTION

Reference will now be made in detail to the exemplary embodiments consistent with the present invention, an example of which is illustrated in the accompanying drawings. Wherever possible, the same reference numbers will be used throughout the drawings to refer to the same or like parts. It is apparent, however, that the embodiments shown in the accompanying drawings are not limiting, and that modifications may be made without departing from the spirit and scope of the invention.

FIG. **1** is an exploded perspective view of a light fixture assembly **10** consistent with the present invention. Light fixture assembly **10** includes a front cover **100**, a LED assembly **200**, a socket **300**, and a thermally-conductive housing **400**.

FIG. **2** is an exploded perspective view of LED assembly **200**. LED assembly **200** may include a reflector, or optic, **210**; a first shell **220**; a lighting element, such as an LED **230**; a thermally conductive material **240**; a printed circuit board **250**; a second shell **260**; a thermal interface member **270**; and a thermal pad **280**.

First shell **220** may include an opening **221** adapted to receive optic **210**, which may be fixed to first shell **220** through an optic-attaching member **222**. First shell **220** may also include one or more airflow apertures **225** so that air may pass through airflow apertures **225** and ventilate printed circuit board **250**, LED **230**, and thermally-conductive housing **400**. First shell **220** may also include one or more engaging members **223**, such as protrusions, on its outer surface **224**. While in this exemplary embodiment engaging members **223** are shown as being "T-shaped" tabs, engaging members **223** can have a variety of shapes and can be located at various positions and/or on various surfaces of LED assembly **200**. Furthermore, the number of engaging members **223** is not limited to the embodiment shown in FIG. **2**. Additionally, the number, shape and/or location of airflow apertures **225** can also be varied. However, in certain applications, ventilation may not be required, and airflow apertures **225** may thus be omitted.

Second shell **260** may include a resilient member, such as resilient ribs **263**. The thickness and width of ribs **263** can be adjusted to increase or decrease compression force, and the openings between ribs **263** can vary in size and/or shape. Ribs **263** in second shell **260** are formed so as to provide proper resistance to create compression for thermal coupling of LED assembly **200** to thermally-conductive housing **400**. Second shell **260** may also include one or more positioning elements **264** that engage with one or more recesses **251** in printed circuit board **250** to properly position printed circuit board **250** and to hold printed circuit board **250** captive between first shell **220** and second shell **260**. Positioning elements **264** may also engage with receivers (not shown) in first shell **220**. First and second shells **220** and **260** may be made of a plastic or resin material such as, for example, polybutylene terephthalate.

As shown in FIG. **2**, the second shell **260** may also include an opening **261** adapted to receive thermal interface member **270**, which may be fixed to (1) second shell **260** through one or more attachment members **262**, such as screws or other known fasteners and (2) a thermal pad **280** to create thermal interface member assembly **299**. Thermal interface member **270** may include an upper portion **271**, and a lower portion **272** with a circumference smaller than the circumference of upper portion **271**. As shown in FIG. **3**, lower portion **272** may be inserted through opening **261** of second shell **260** such that upper portion **271** engages with second shell **260**. Second shell **260** may be formed of for example, nylon and/or thermally conductive plastics such as plastics made by Cool Polymers, Inc., known as CoolPoly®.

Referring now to FIG. **2**, thermal pad **280** may be attached to thermal interface member **270** through an adhesive or any other appropriate known fastener so as to fill microscopic gaps and/or pores between the surface of the thermal interface member **270** and thermally-conductive housing **400**. Thermal pad **280** may be any of a variety of types of commercially available thermally conductive pad, such as, for example, Q-PAD 3 Adhesive Back, manufactured by The Bergquist Company. While thermal pad **280** is used in this embodiment, it can be omitted in some embodiments.

As shown in FIG. **2**, lower portion **272** of thermal interface member **270** may serve to position LED **230** in LED assembly **200**. LED **230** may be mounted to a surface **273** of lower portion **272** using fasteners **231**, which may be screws or other well-known fasteners. A thermally conductive material **240** may be positioned between LED **230** and surface **273**.

The machining of both the bottom surface of LED **230** and surface **273** during the manufacturing process may leave minor imperfections in these surfaces, forming voids. These voids may be microscopic in size, but may act as an impedance to thermal conduction between the bottom surface of LED **230** and surface **273** of thermal interface **270**. Thermally conductive material **240** may act to fill in these voids to reduce the thermal impedance between LED **230** and surface **273**, resulting in improved thermal conduction. Moreover, consistent with the present invention, thermally conductive material **240** may be a phase-change material which changes from a solid to a liquid at a predetermined temperature, thereby improving the gap-filling characteristics of the thermally conductive material **240**. For example, thermally conductive material **240** may include a phase-change material such as, for example, Hi-Flow 225UT 003-01, manufactured by The Bergquist Company, which is designed to change from a solid to a liquid at 55° C.

While in this embodiment thermal interface member **270** may be made of aluminum and is shown as resembling a "top hat," various other shapes, sizes, and/or materials could be used for the thermal interface member to transport and/or spread heat. As one example, thermal interface member **270** could resemble a "pancake" shape and have a single circumference. Furthermore, thermal interface member **270** need not serve to position the LED **230** within LED assembly **200**. Additionally, while LED **230** is shown as being mounted to a substrate **238**, LED **230** need not be mounted to substrate **238** and may instead be directly mounted to thermal interface member **270**. LED **230** may be any appropriate commercially available single- or multiple-LED chip, such as, for example, an OSTAR 6-LED chip manufactured by OS RAM GmbH, having an output of 400-650 lumens.

FIG. **4** is a perspective view of socket **300** including one or more engaging members, such as angled slot **310** arranged on inner surface **320** of LED socket **300**. Slot **310** includes a receiving portions **311** that receives and is engageable with a respective engaging member **223** of first shell **220** at an alignment position, a lower portion **312** that extends circumferentially around a portion of the perimeter of LED socket **300** and is adapted to secure LED assembly **200** to LED socket **300**, and a stopping portion **313**. In some embodiments, stopping portion **313** may include a protrusion (not shown) that is also adapted to secure LED assembly **200** to LED socket **300**. Slot **310** may include a slight recess **314**, serving as a locking mechanism for engaging member **223**. Socket **300** also includes a front cover retaining mechanism **330** adapted to engage with a front cover engaging member **101** in front cover **100** (shown in FIGS. **1** and **10**). A front cover retaining mechanism lock **331** (FIG. **5**) is provided such that when front cover retaining mechanism **330** engages with and is rotated with respect to front cover engaging member **101**, the front cover retaining mechanism lock holds the front cover **100** in place. Socket **300** may be fastened to thermally-conductive housing **400** through a retaining member, such as retaining member **340** using a variety of well-known fasteners, such as screws and the like. Socket **300** could also have a threaded outer surface that engages with threads in thermally-conductive housing **400**. Alternatively, socket **300** need not be a separate element attached to thermally-conductive housing **400**, but could be integrally formed in thermally-conductive housing **400** itself. Additionally, as shown in FIG. **7**, socket **300** may also include a tray **350** which holds a terminal block **360**, such as a battery terminal connector.

Referring now to FIG. **5**, to mount LED assembly **200** in socket **300**, LED assembly **200** is placed in an alignment position, in which engaging members **223** of LED assembly **200** are aligned with receiving portions **311** of angled slots **310** of socket **300**. In one embodiment, LED assembly **200** and socket **300** may have a circular perimeter and, as such, LED assembly **200** may be rotated with respect to socket **300** in the direction of arrow A in FIG. **4**. As shown in FIG. **5**, when LED assembly **200** is rotated, engaging members **223** travel down receiving portions **311** into lower portions **312** of angled slots **310** until engaging members **223** meet stopping portion **313**, which limits further rotation and/or compression of LED assembly **200**, thereby placing LED assembly **200** and socket **300** in an engagement position.

Referring now to FIGS. **6**A and **6**B, second shell **260** is shown in compressed and uncompressed states, respectively. The rotation of LED assembly **200**, and the pressing of engaging members **223** on upper surface **314** of angled slots **310** causes resilient ribs **263** of second shell **260** to deform axially inwardly which may decrease the height H_c of LED assembly **200** with respect to the height H_u of LED assembly **200** in an uncompressed state. Referring back to FIG. **5**, as engaging members **223** descend deeper down angled slot **310**, the compression force generated by resilient ribs **263** increases. This compression force lowers the thermal impedance between LED assembly **200** and thermally-conductive housing **400**. Engaging members **223** and angled slots **310** thus form a compression element.

FIG. **9** is a perspective cross-sectional view of an exemplary embodiment of a light fixture assembly showing LED assembly **200** in a compressed state such that it is thermally and electrically connected to thermally-conductive housing **400**. As shown in FIG. **6**B, if LED assembly **200** is removed from socket **300**, resilient ribs **263** will return substantially to their initial undeformed state.

Additionally, as shown in FIGS. **8**A and **8**B, the rotation of LED assembly **200** forces printed circuit board electrical contact strips **252** on printed circuit board **250** into engagement with electrical contacts **361** of terminal block **360**, thereby creating an electrical connection between LED assembly **200** and electrical contacts **361** of housing **400**, so that operating power can be provided to LED **230**. Alternate means may also be provided for supplying operating power to LED **230**. For example, LED assembly **200** may include an electrical connector, such as a female connector for receiving a power cord from housing **400** or a spring-loaded electrical contact mounted to the LED assembly **200** or the housing **400**.

As shown in FIG. **7**, while in this embodiment receiving portions **311** of angled slots **310** are the same size, receiving portions **311**, angled slots **310**, and/or engaging members **223** may be of different sizes and/or shapes. For example, receiving portions **311** may be sized to accommodate a larger engaging member **223** so that LED assembly **200** may only be inserted into socket **300** in a specific position. Additionally, the location and number of angled slots **310** are not limited to the exemplary embodiment shown in FIG. **7**.

Furthermore, while the above-described exemplary embodiment uses angled slots, other types of engagement between LED assembly **200** and LED socket **300** may be used to create thermal and electrical connections between LED assembly **200** and thermally-conductive housing **400**.

As shown in FIG. **11**, in a second exemplary embodiment of a light fixture assembly, LED assembly **230** may be mounted to a thermal interface member **270**, which may include a male threaded portion **232** with a first button-type electrical contact **233** insulated from threaded portion **232**. Male threaded portion **232** of thermal interface member **270** could rotatably engage with, for example, a female threaded portion **332** of socket **300**, such that one or both of male and female threaded portions **232**, **332** slightly deform to create compressive force such that first electrical contact **233** comes into contact with second button-type electrical contact **333** and the thermal impedance between thermal interface member **270** and housing **400** is lowered. A thermal pad **280** with a circular center cut-out may be provided at an end portion of male threaded portion **232**. The thermal pad **280** can have resilient features such that resilient thermal interface pad **280** acts as a spring to create or increase a compression force to lower the thermal impedance between thermal interface member **270** and housing **400**. Male and female threaded portions **232**, **332** thus form a compression element.

As shown in FIG. **12**, in a third exemplary embodiment of a light fixture assembly, a resilient thermal interface pad **500** may be provided at an end portion of thermal interface member **270** such that resilient thermal interface pad **500** acts to create a compression force for low thermal impedance coupling. Socket **300** may include tabs **395** that engage with slots in thermal interface member **270** to form a compression element and create additional compression as well as to lock the LED assembly into place.

As shown in FIG. **13**, in a fourth exemplary embodiment of a light fixture assembly, thermal interface member **270** may have a buckle catch **255** that engages with a buckle **355** on thermally-conductive housing **400**, thus forming a compression element. As shown in FIG. **14**, in a fifth exemplary embodiment of a light fixture assembly, a fastener such as screw **265** may attach to a portion **365** of heat-dissipating fixture housing **400** so as to form a compression element and create the appropriate compressive force to provide low impedance thermal coupling between thermal interface member **270** and thermally-conductive housing **400**.

Referring back to FIG. **1**, after LED assembly **200** is installed in thermally-conductive housing **400**, a front cover **100** may be attached to socket **300** by engaging front cover engaging member **101** on the front cover **100** with front cover retaining mechanism **330**, and rotating front cover **100** with respect to socket **300** to secure front cover **100** in place. Front cover **100** may include a main aperture **102** formed in a center portion of cover **100**, a transparent member, such as a lens **104** formed in aperture **102**, and a plurality of peripheral holes **106** formed on a periphery of front cover **100**. Lens **104** allows light emitted from a lighting element to pass through cover **100**, while also protecting the lighting element from the environment. Lens **102** may be made from any appropriate transparent material to allow light to flow therethrough, with minimal reflection or scattering.

As shown in FIG. **1**, and consistent with the present invention, front cover **100**, LED assembly **200**, socket **300**, and thermally-conductive housing **400** may be formed from materials having a thermal conductivity k of at least 12, and preferably at least 200, such as, for example, aluminum, copper, or thermally conductive plastic. Front cover **100**, LED assembly **200**, socket **300**, and thermally-conductive housing **400** may be formed from the same material, or from different materials. Peripheral holes **106** may be formed on the periphery of front cover **100** such that they are equally spaced and expose portions along an entire periphery of the front cover **100**. Although a plurality of peripheral holes **106** are illustrated, embodiments consistent with the present invention may use one or more peripheral holes **106** or none at all. Consistent with an embodiment of the present invention, peripheral holes **106** are designed to allow air to flow through front cover **100**, into and around LED assembly **200** and flow through air holes in thermally-conductive housing **400** to dissipate heat.

Additionally, as shown in FIG. **1**, peripheral holes **106** may be used to allow light emitted from LED **230** to pass through peripheral holes **106** to provide a corona lighting effect on front cover **100**. Thermally-conductive housing **400** may be made from an extrusion including a plurality of surface-area increasing structures, such as ridges **402** (shown in FIG. **1**) as described more completely in co-pending U.S. patent application Ser. No. 11/715,071 assigned to the assignee of the present invention, the entire disclosure of which is hereby incorporated by reference in its entirety. Ridges **402** may serve multiple purposes. For example, ridges **402** may provide heat-dissipating surfaces so as to increase the overall surface area of thermally-conductive housing **400**, providing a greater surface area for heat to dissipate to an ambient atmosphere over. That is, ridges **402** may allow thermally-conductive housing **400** to act as an effective heat sink for the light fixture assembly. Moreover, ridges **402** may also be formed into any of a variety of shapes and formations such that thermally-conductive housing **400** takes on an aesthetic quality. That is, ridges **402** may be formed such that thermally-conductive housing **400** is shaped into an ornamental extrusion having aesthetic appeal. However, thermally-conductive housing **400** may be formed into a plurality of other shapes, and thus function not only as a ornamental feature of the light fixture assembly, but also as a heat sink for cooling LED **230**.

Other embodiments of the invention will be apparent to those skilled in the art from consideration of the specification and practice of the invention disclosed herein. It is intended that the specification and examples be considered as exemplary only, with a true scope and spirit of the invention being indicated by the following claims.

What is claimed is:

1. A lighting assembly, comprising:

a light fixture;

a light module comprising an LED lighting element and removably coupleable to the light fixture; and

one or more resilient members configured to generate an axial force when the light module is removably coupled to the light fixture to thereby exert a force on at least a portion of the light module to resiliently maintain at least a portion of the light module in resilient contact with a surface of the light fixture or socket of the light fixture to thereby thermally couple at least a portion of the light module to the light fixture or socket of the light fixture,

wherein one or both of the light module and light fixture comprises one or more engaging members that extend from a surface thereof, and wherein one or both of the light module and the light fixture comprises one or more slots configured to removably receive the one or more engaging members therein when coupling the light module to the light fixture.

2. The lighting assembly of claim **1**, wherein the light fixture comprises a socket, one or more of said slots defined on a surface of the socket.

3. The lighting assembly of claim **2**, wherein the one or more slots in the socket have a surface at least a portion of which is generally inclined toward a bottom of the socket, one or more of the engaging members configured to engage said inclined surface as the light module is rotated relative to the socket during coupling of the light module to the socket such that the engagement between the engaging members and the inclined surface causes at least a portion of the light module to axially move toward the bottom of the socket as the light module is rotated relative to the socket.

4. The lighting assembly of claim **2**, wherein the one or more slots are defined on an inner surface of the socket, said inner surface defining a cylindrical recess configured to removably receive at least a portion of the light module therein when coupling the light module to the socket.

5. The lighting assembly of claim **4**, wherein the one or more slots in the socket have a generally horizontal surface between an end of the inclined surface and a generally vertical stop portion configured to prevent further rotation of the light module relative to the socket, the horizontal surface separated from the inclined surface by a protrusion, the one or more slots configured to hold the one or more engaging members in a releasably locked position when said one or more engaging members are disposed between the protrusion and the generally vertical stop portion.

6. The lighting assembly of claim **1**, wherein the force axially drives a base surface of the light module into resilient contact with a surface of the light fixture to thereby thermally couple the light module to the light fixture.

7. The lighting assembly of claim **1**, wherein the one or more engaging members extend radially from a surface of the light module.

8. The lighting assembly of claim **1**, wherein the one or more resilient members are disposed in the light module between a front end and a base surface of the light module.

9. The lighting assembly of claim **2**, wherein the light module further comprises one or more electrical contact members configured to releasably contact one or more electrical contacts of the socket to provide an operative electrical connection between the light module and the socket when the light module is coupled to the socket.

10. The lighting assembly of claim **1**, wherein the LED lighting element is rotationally fixed relative to the one or more engaging members, such that the LED lighting element rotates together with the one or more engaging members and the rest of the light module when the light module is rotated.

11. A light module removably coupleable to a light fixture, the light module comprising:

a generally cylindrical housing;

an LED lighting element at least partially disposed in the housing;

one or more electrical contact members configured to releasably contact one or more electrical contacts of a socket of a light fixture to provide an operative electrical connection between the light module and the socket of the light fixture when the light module is coupled to the light fixture; and

one or more engaging members on the housing, the engaging members configured to releasably engage corresponding one or more engaging elements in the socket of the light fixture when coupling the light module to the socket,

wherein the engagement of the engaging members with the engaging elements of the socket generates an axial force that maintains at least a portion of the light module into resilient contact with a surface of a light fixture or socket of the light fixture when coupling the light module to the socket to thereby thermally couple the light module to the light fixture or socket of the light fixture.

12. The light module of claim **11**, wherein the one or more engaging members extend radially outward from a circumferential surface of the housing.

13. The light module of claim **11**, wherein the LED lighting element is rotationally fixed relative to the housing and the one or more engaging members, such that the LED lighting element rotates together with the housing and the one or more engaging members when the light module is rotated.

14. The light module of claim **11**, wherein the one or more engaging elements of the socket comprise one or more slots in a surface of the socket.

15. The light module of claim **11**, wherein engagement of the engaging members with the engaging elements of the socket axially drives a base surface of the light module into resilient contact with a surface of a light fixture or socket of the light fixture when coupling the light module to the socket to thereby thermally couple the light module to the light fixture or socket of the light fixture.

16. The light module of claim **11**, further comprising one or more resilient members disposed between a front end and a base surface of the light module, the resilient members configured to flex when the light module is coupled to the light fixture, thereby generating a force that maintains the base surface in resilient contact with the surface of the light fixture to thereby thermally couple the light module to the light fixture or socket of the light fixture.

17. The light module of claim **11**, wherein the one or more electrical contact members comprise electrical contact strips on a bottom surface of the light module.

18. A light module for use in a lighting assembly, comprising:

an LED lighting element;

a thermal interface member operatively coupled to the LED lighting element, the thermal interface member configured to contact one or more thermally conductive surfaces of at least one of a socket and a heat dissipating member of the lighting assembly when the LED module is coupled to the socket;

one or more resilient members of the LED module configured to move from a first position to a second position to generate an axial force between the LED module and at least one of the socket and the heat dissipating member when the LED module is coupled to the socket, thereby causing the LED module to thermally contact said one or more thermally conductive surfaces; and

one or more electrical contact members of the LED module configured to releasably contact one or more electrical contacts of the socket when the LED module is coupled to the socket to thereby provide an operative electrical connection to the LED.

19. The light module of claim **18**, wherein the one or more resilient members are disposed between a front end and a base surface of the light module, the resilient members configured to flex when the light module is coupled to the lighting assembly, thereby generating a force that axially drives the base surface into resilient contact with said one or more thermally conductive surfaces.

20. The light module of claim **18**, wherein the one or more electrical contact members are electrical contact strips on a bottom surface of the light module.

21. A light module for use in a lighting assembly, comprising:

an LED lighting element;

a thermal interface member operatively coupled to the LED lighting element, the thermal interface member configured to contact at least one of a socket and a heat dissipating member of the lighting assembly when the light module is installed therein; and

at least one buckle catch attached to the light module, the buckle catch configured to releasably engage a buckle on the lighting assembly to couple the light module to the lighting assembly to fixedly position the light module relative to the socket.

22. The light module of claim **21**, wherein the coupling of the buckle and buckle catch generates a compression force between the light module and the lighting assembly.

23. The light module of claim **21**, further comprising one or more electrical contacts configured to contact an electrical element on the lighting assembly when the light module is coupled to the lighting assembly.

24. A lighting assembly, comprising:

a light fixture assembly comprising a heat dissipating member and at least one buckle mechanism; and

a light module configured to couple to the heat dissipating member, the light module comprising

an LED lighting element;

a thermal interface member operatively coupled to the LED lighting element, the thermal interface member configured to contact at least a portion of the heat dissipating member when the light module is coupled to the light fixture assembly; and

at least one buckle catch attached to the light module, the buckle catch configured to releasably engage the at least one buckle mechanism of the light fixture assembly to couple the light module to the light fixture assembly to fixedly position the light module relative to the light fixture assembly,

wherein the buckle mechanism is movable from an open position to a closed position, the buckle mechanism engaging the buckle catch in the closed position so as to generate a compression force between the light module and the light fixture assembly.

25. The lighting assembly of claim **24**, wherein the light module further comprises one or more electrical contacts configured to contact an electrical element on the light fixture assembly when the light module is coupled to the light fixture assembly.

26. A lighting assembly, comprising:

a light fixture having a thermally conductive member;

an LED light module removably coupleable to the light fixture, the light module comprising:

an LED lighting element;

a thermal interface member coupled to the LED lighting element and configured to resiliently contact the thermally-conductive member when the LED module is coupled to a socket of the light fixture; and

a printed circuit board electrically connected to the LED lighting element, the printed circuit board comprising one or more electrical contact members configured to contact one or more electrical contacts on the socket when the LED light module is installed in the light fixture; and

a compression element configured to move from a first position to a second position to generate a compression force between the LED light module and the thermally conductive member, causing the LED light module to become thermally connected to one or more thermally conductive surfaces of the thermally conductive member when the LED light module is installed in the light fixture.

27. The lighting assembly of claim **26**, wherein the compression element is part of the LED light module.

28. A lighting assembly, comprising:

a light module comprising an LED lighting element; and

a socket associated with a light fixture and configured to releasably couple to the light module,

wherein the light module or socket have one or more resilient members configured to generate an axial force when the light module is removably coupled to the socket to thereby exert a force on at least a portion of the light module to resiliently maintain at least a portion of the light module in resilient contact with a thermally conductive surface of the light fixture or socket to thereby thermally couple at least a portion of the light module to the thermally conductive surface,

and wherein one or both of the light module and the socket comprises one or more engaging members that extend from a surface thereof, and wherein one or both of the light module and the socket comprises one or more recesses that removably receive the one or more engaging members therein when coupling the light module to the socket.

* * * * *

UNITED STATES PATENT AND TRADEMARK OFFICE

CERTIFICATE OF CORRECTION

PATENT NO. : 8,562,180 B2
APPLICATION NO. : 13/464191
DATED : October 22, 2013
INVENTOR(S) : Clayton Alexander et al.

It is certified that error appears in the above-identified patent and that said Letters Patent is hereby corrected as shown below:

In the Specification

At column 4, line 46, please delete “locket” and insert -- socket --, therefor.

At column 6, line 44, please delete “of” and insert -- of, --, therefor.

Signed and Sealed this
Twenty-second Day of July, 2014

Michelle K. Lee

Deputy Director of the United States Patent and Trademark Office